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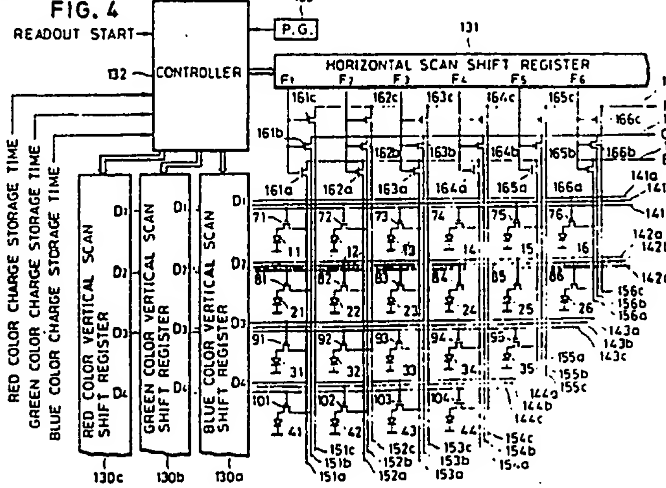
INT CL⁴ **H04N**

(54) Colour image sensor

(57) A colour image sensor has: blue, green and red colour photodiodes 11,12,13 etc for converting light into a charge signal and storing it, the blue, green and red colour photodiodes being disposed in a matrix fashion. Three vertical lines 151a,b,c; 152a,b,c; etc are provided for each column to pick up the charge signals stored in the photodiodes via vertical MOS switches 71-76, 81-86, etc. The vertical MOS switches are serially connected to respective horizontal MOS switches 161a,b,c; 162a,b,c; etc which are turned on by a horizontal scan shift register 131. If the concurrent readout of colour signals is not required, a single horizontal scan shift register is used, otherwise three shift registers may be provided (Fig. 2). Three vertical scan shift registers are provided so that each colour is read out independently. By varying the operating timings of the three vertical scan shift registers, the charge storage time for each colour can be controlled. The photodiodes in the form of a matrix arrangement are grouped into units each constructed of *M* rows and *N* columns. A one pixel measuring unit is constructed of one grouped unit.

FIG. 4



The date of filing shown above is that provisionally accorded to the application in accordance with the provisions of Section 15(4) of the Patents Act 1977 [illegible]

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FIG. 1

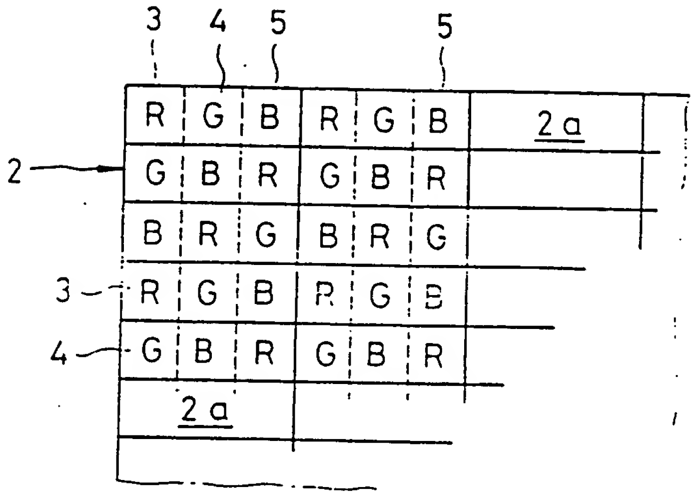
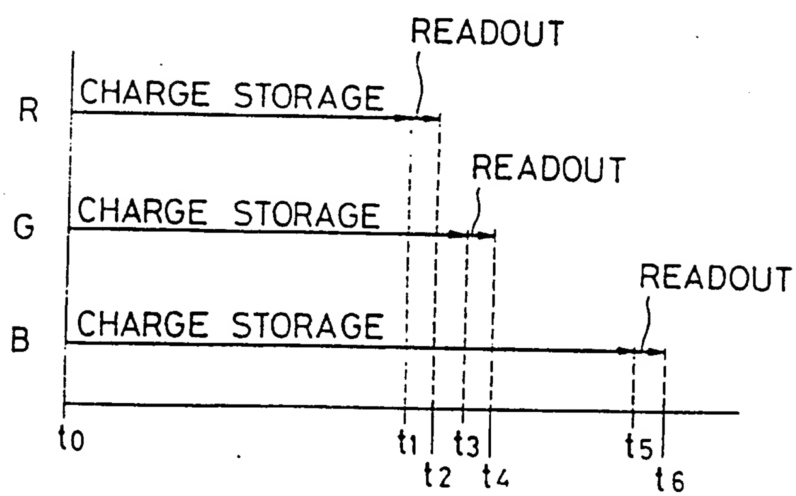

3
4
5
5
R G B R G B
G B R G B R
B R G B R G
R G B R G B
G B R G B R
2a
2
3
4
2a

FIG. 3


READOUT
R
CHARGE STORAGE
READOUT
G
CHARGE STORAGE
READOUT
B
CHARGE STORAGE
t0
t1
t2
t3
t4
t5
t6

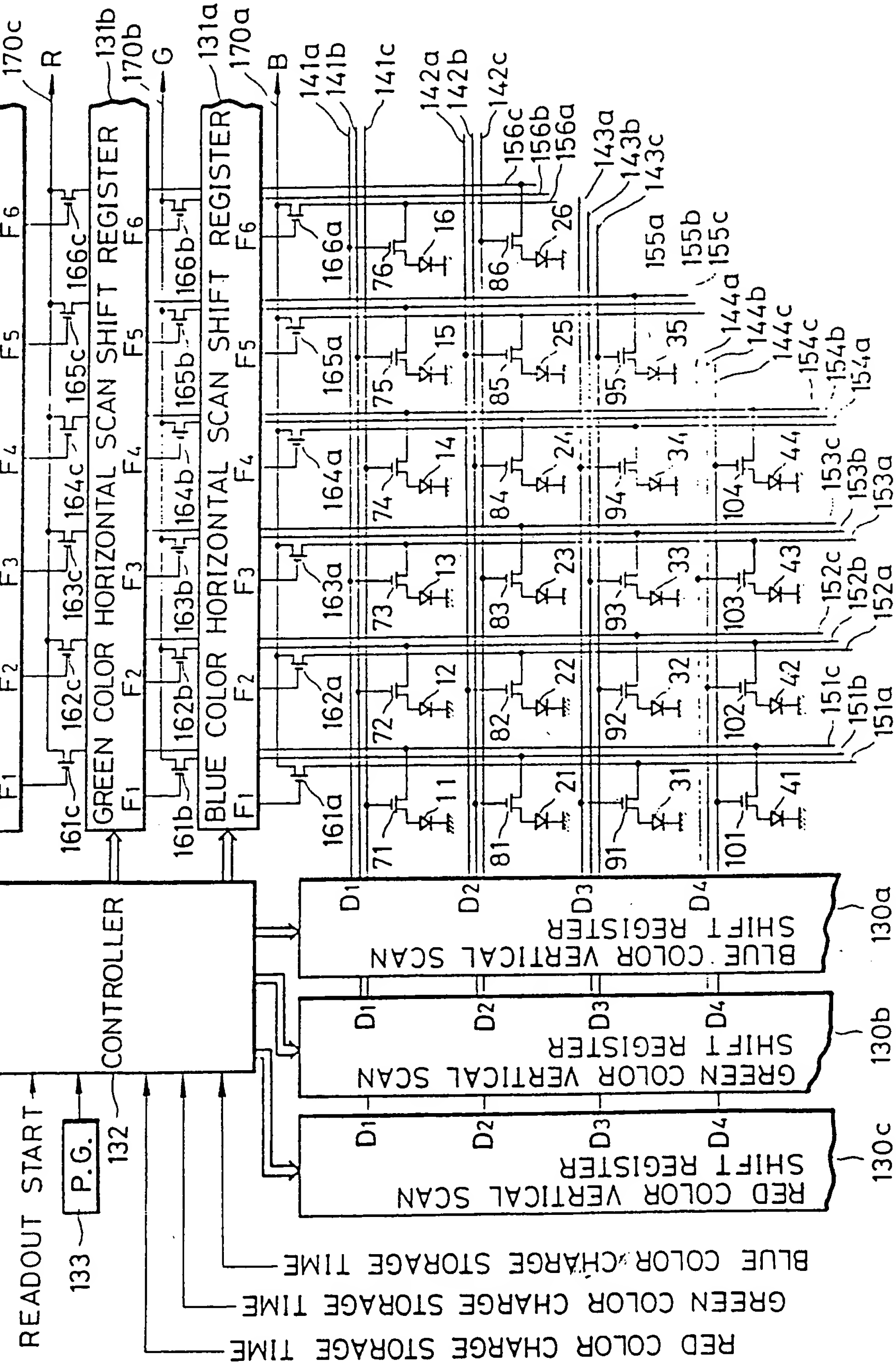

RED COLOR HORIZONTAL SCAN SHIFT REGISTER
GREEN COLOR HORIZONTAL SCAN SHIFT REGISTER
BLUE COLOR HORIZONTAL SCAN SHIFT REGISTER
F1
F2
F3
F4
F5
F6
131a
131b
131c
170a
170b
170c
R
G
B
CONTROLLER
BLUE COLOR VERTICAL SCAN SHIFT REGISTER
GREEN COLOR VERTICAL SCAN SHIFT REGISTER
RED COLOR VERTICAL SCAN SHIFT REGISTER
D1
D2
D3
D4
130a
130b
130c
READOUT START
P.G.
132
133
BLUE COLOR CHARGE STORAGE TIME
GREEN COLOR CHARGE STORAGE TIME
RED COLOR CHARGE STORAGE TIME

FIG.2

FIG. 4

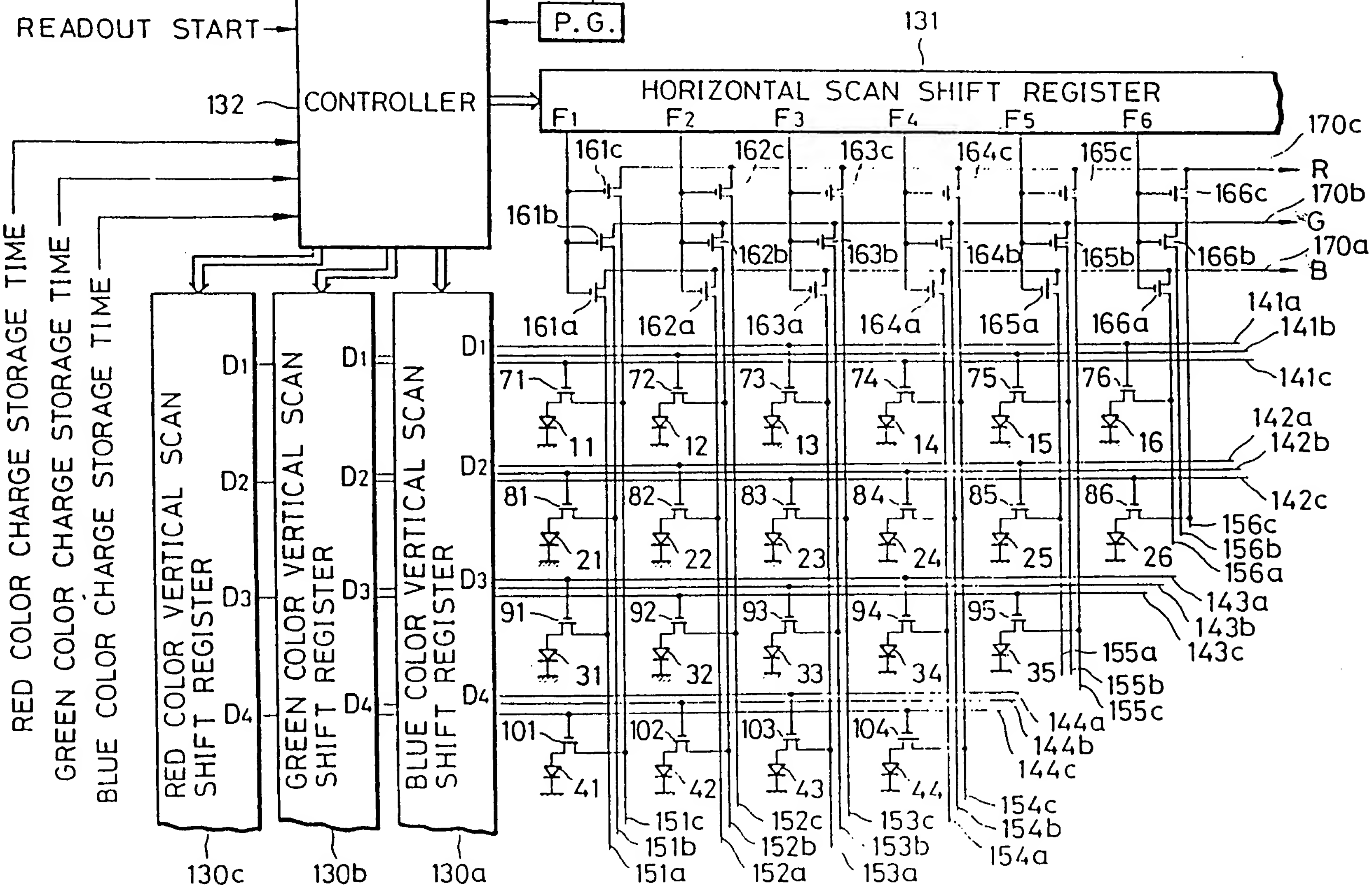

READOUT START
CONTROLLER
132
P.G.
133
HORIZONTAL SCAN SHIFT REGISTER
131
F1
F2
F3
F4
F5
F6
RED COLOR CHARGE STORAGE TIME
GREEN COLOR CHARGE STORAGE TIME
BLUE COLOR CHARGE STORAGE TIME
RED COLOR VERTICAL SCAN SHIFT REGISTER
GREEN COLOR VERTICAL SCAN SHIFT REGISTER
BLUE COLOR VERTICAL SCAN SHIFT REGISTER
130c
130b
130a
D1
D2
D3
D4
R
G
B
170a
170b
170c
161a
161b
161c
162a
162b
162c
163a
163b
163c
164a
164b
164c
165a
165b
165c
166a
166b
166c
141a
141b
141c
142a
142b
142c
143a
143b
143c
144a
144b
144c
151a
151b
151c
152a
152b
152c
153a
153b
153c
154a
154b
154c
155a
155b
155c
156a
156b
156c
71
72
73
74
75
76
81
82
83
84
85
86
91
92
93
94
95
101
102
103
104
11
12
13
14
15
16
21
22
23
24
25
26
31
32
33
34
35
41
42
43
44

FIG. 5

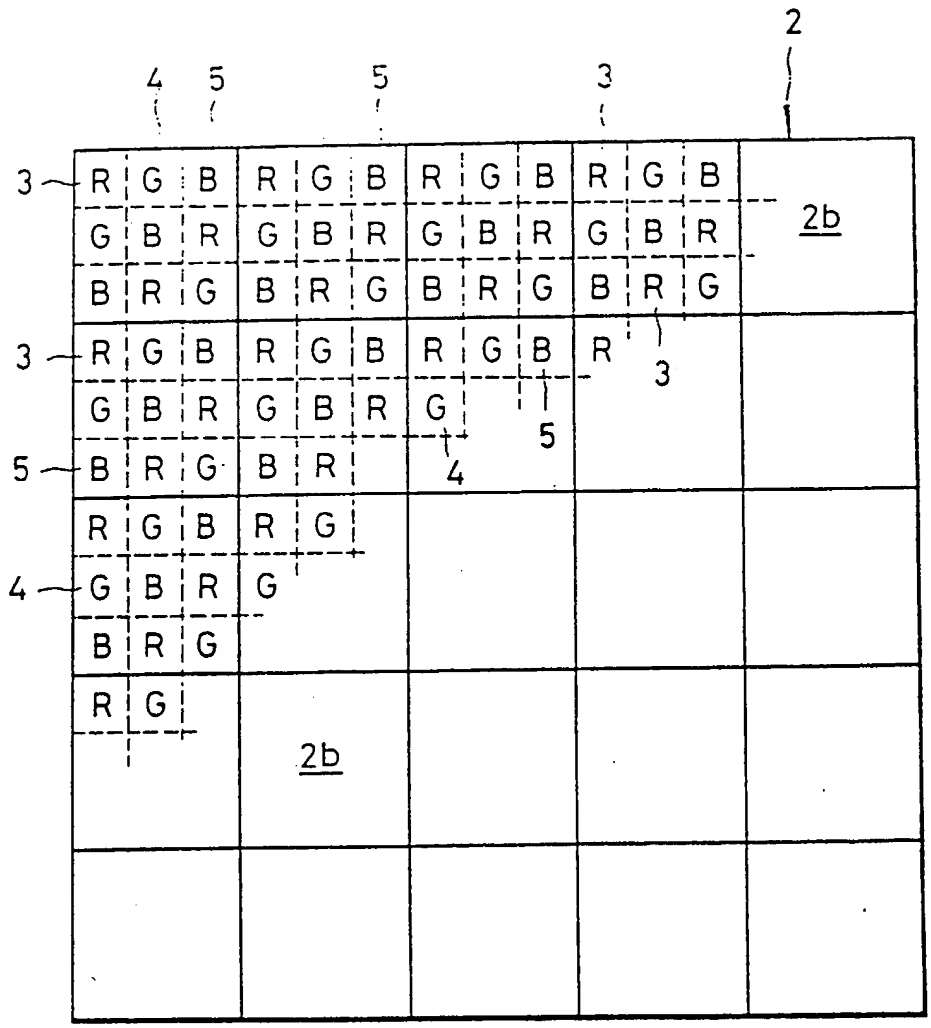
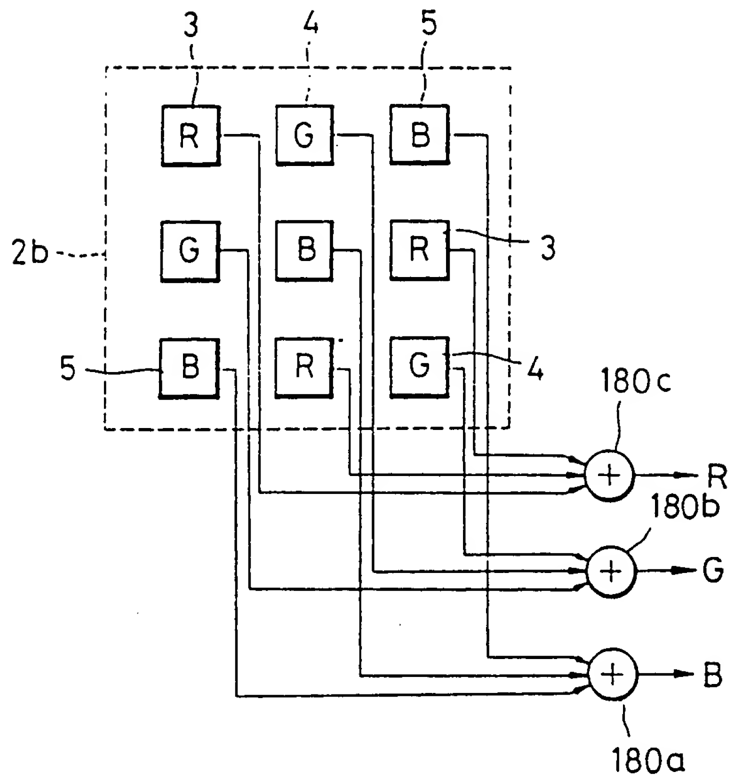
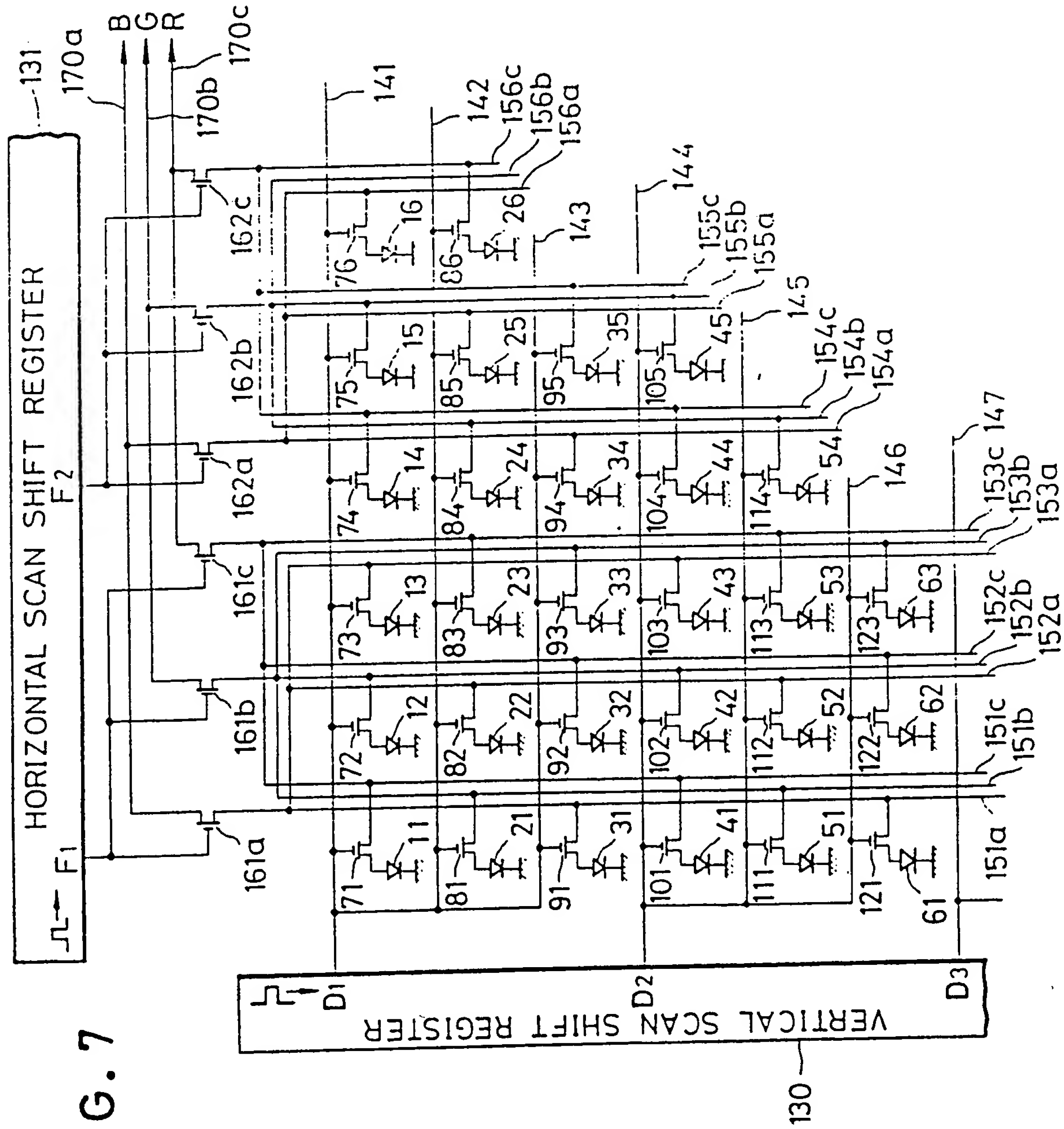

2
4
5
5
3
3
R G B R G B R G B R G B
2b
G B R G B R G B R G B R
B R G B R G B R G B R G
3
R G B R G B R G B R
3
G B R G B R G
5
4
5
B R G B R
R G B R G
4
G B R G
B R G
R G
2b

FIG. 6





HORIZONTAL SCAN SHIFT REGISTER
F1
F2
131
170a
170b
170c
B
G
R
161a
161b
161c
162a
162b
162c
141
142
143
144
145
146
147
151a
151b
151c
152a
152b
152c
153a
153b
153c
154a
154b
154c
155a
155b
155c
156a
156b
156c
VERTICAL SCAN SHIFT REGISTER
D1
D2
D3
130

FIG. 7

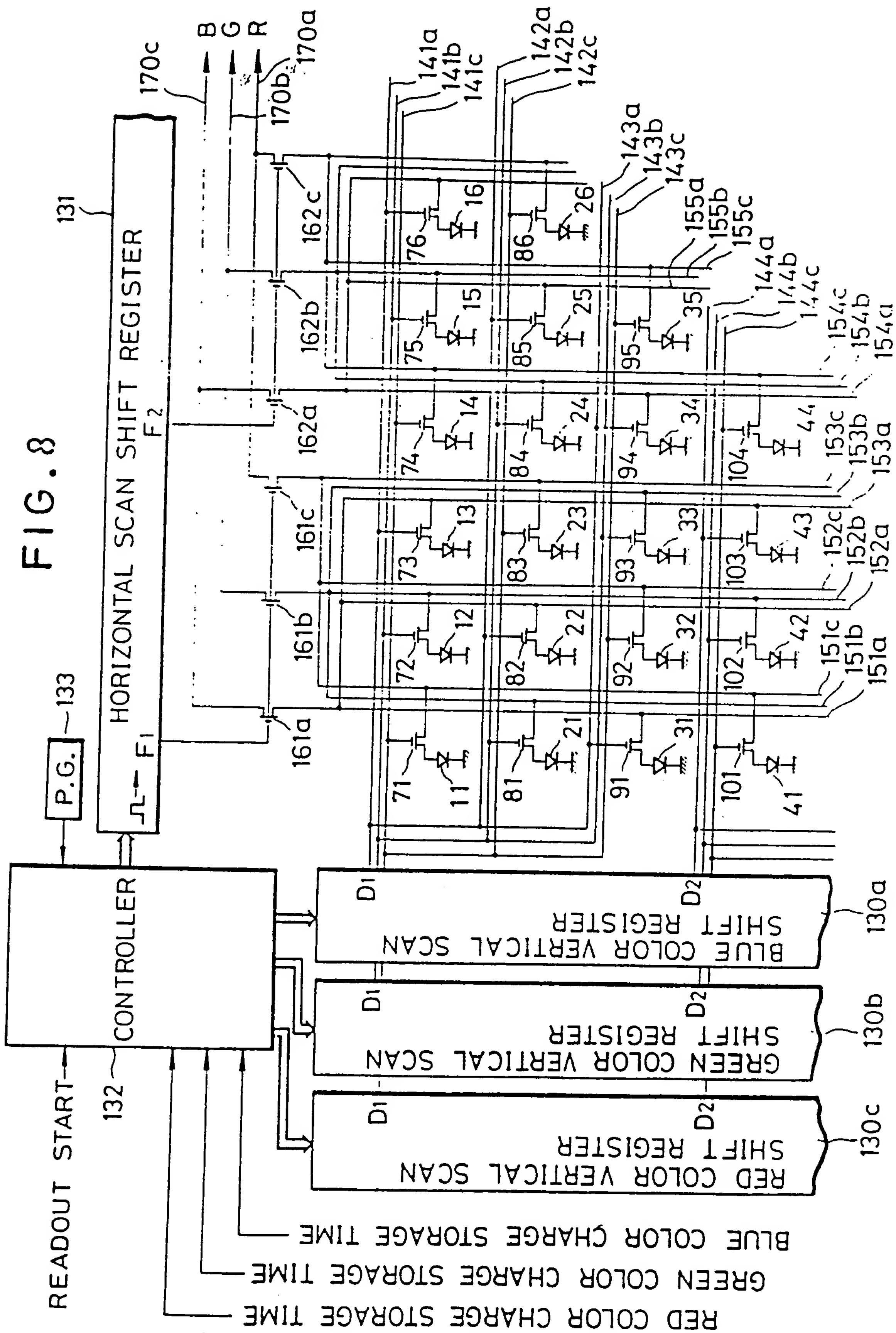

HORIZONTAL SCAN SHIFT REGISTER
CONTROLLER
P.G.
BLUE COLOR VERTICAL SCAN SHIFT REGISTER
GREEN COLOR VERTICAL SCAN SHIFT REGISTER
RED COLOR VERTICAL SCAN SHIFT REGISTER
READOUT START
BLUE COLOR CHARGE STORAGE TIME
GREEN COLOR CHARGE STORAGE TIME
RED COLOR CHARGE STORAGE TIME
B
G
R

FIG. 8

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COLOR IMAGE SENSOR

The present invention relates to a color image sensor for reading a color image, and more particularly to a color image sensor suitable for use as a scanner of a color printer.

A recent color printer is provided with a scanner for scanning a color original (color negative film, color positive film and the like). To reproduce a color print having proper densities and well-balanced colors, three color densities of the color original are measured at each point of the color original to control the exposure quantities of red, green and blue colors at the time of printing a color paper on the basis of the measured three color densities. A color image sensor is used in the scanner, which may be either a three image sensor type scanner or a single image sensor type scanner: the former type scannersare provided with three color image sensors, e.g., red, green and blue color image sensors for each color to be measured, and the latter type scanner is provided with a single image sensor and a mosaic or stripe filter which is disposed at the light receiving surface of the single image sensor and has red, green and blue color transmission areas disposed alternately to each other.

The three image sensor type scanner requires not only three color image sensors but also three sets of drivers and optical systems, thus resulting in a complicated structure and an

expensive cost. Therefore, a single image sensor type scanner is more advantageous in view of the cost and the space required for mounting the scanner. In the single image sensor type scanner which has already been adopted in a color TV camera, three color signals for each pixel are mixed and collected by the scanner. However, in a color printer, it is necessary for a computer to be supplied with a separate color signal for each color in order to calculate the exposure quantity of each color. Therefore, in the case where a single image sensor type color scanner is used for color printing, a color separation circuit of a complicated structure, which operates in synchrony with reading of the color image sensor, is required between the color image sensor and the computer.

In measuring the three color densities of a color original with a single image sensor type color scanner, color registration error is generated inevitably since each photoelectric conversion unit measures a different point. Consequently, a correct measurement of each pixel is not possible. This becomes a problem when the three color exposure quantities are controlled taking the hue of each pixel into consideration.

Generally speaking, color negative films made by an amateur include adequately exposed frames, over-exposed frames or under-exposed frames. Thus, a dynamic range of about 10000 steps is necessary for measuring the density of an image of a color negative film. However, the dynamic range of a color image sensor is narrow so that if 10000 steps are to be covered, a change in signal level due to a change in incident light must be suppressed, which makes it impossible to measure the density with high accuracy. Apart from the above, if a single frame is here

considered, a dynamic range of about 100 steps can suffice for each color although the signal level differs for each color. Therefore, if the density is measured by changing the charge storage time for each color, the dynamic range is substantially widened so that a signal with less noise can be obtained.

OBJECTS OF THE INVENTION

It is therefore an object of the present invention to provide a color image sensor of a single image sensor type in which a plurality of types of photoelectric conversion units are alternately disposed, each photoelectric conversion unit photoelectrically converting a different color light into a charge signal and storing it, wherein a color signal corresponding to the charge signal can be read separately from each other color signal.

It is another object of the present invention to provide a color image sensor with less color registration error.

It is a further object of the present invention to provide a color image sensor capable of obtaining a signal with less noise by setting a charge storage time independently of each color to widen the dynamic range.

SUMMARY OF THE INVENTION

To achieve the above main objects of the present invention, the color image sensor of the invention is provided with readout means for reading the charge signals stored in respective photoelectric conversion units in the form of color-separated signals.

According to a preferred embodiment of the present invention, the photoelectric conversion units disposed in a matrix fashion are grouped into a plurality of one pixel

measuring units each unit comprising M x N (M and N are integers 3 or larger) photoelectric conversion units. Within each one pixel measuring unit, n (minimum common divisor of M x N, integer 3 or larger) photoelectric conversion units are included for each color. The charge signals stored in n photoelectric conversion units are added and read. To effect addition of the charge signals in a one pixel measuring unit, respective vertical MOS switches connected to n photoelectric conversion units are simultaneously turned ON and at the same time one horizontal MOS switch connected to the n vertical MOS switches is turned ON. To simplify the circuit construction, one vertical scan shift register for turning ON vertical MOS switches and one horizontal scan shift register for turning ON horizontal MOS switches are provided to simultaneously read the charge signals for each color.

According to another preferred embodiment of the present invention, to enable a high precision measurement by setting a storage time (photoelectric conversion time) for each color to widen the dynamic range, a vertical scan shift register is provided for each color. Each vertical scan shift register operates independently from each other and turns ON vertical MOS switches at a different timing for each color to thereby terminate the storage of the charge signals. A horizontal MOS switch connected serially to vertical MOS transistors is controlled to turn ON or OFF by the horizontal scan shift register which may be provided for each color or used commonly for all colors. In the case of a single horizontal scan shift register, a simple circuit construction and an economical cost

can be enjoyed. However, vertical scan shift registers provided for respective colors cannot be operated at a time. Therefore, the vertical scan shift registers are selectively operated for reading the charge signals for each color. Grouping of the photoelectric conversion units in units of M x N is effective in eliminating color registration errors.

Various combinations such as blue, green and red, or cyan, magenta and yellow may be used as color lights to all of which the present invention is applicable. Specific color lights such as a flesh tint color light may be used.

Certain embodiments of the invention will now be described by way of example and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is an explanatory view of the arrangement of photoelectric conversion units of the color image sensor according to the present invention.

Fig.2 is a circuit diagram of the color image sensor according to the present invention, wherein vertical shift registers and horizontal shift registers are provided for respective colors and the charge storage time for each color can be varied.

Fig.3 is a timing chart showing the charge storage and signal readout of the embodiment shown in Fig.2.

Fig.4 is a circuit diagram of the color image sensor according to the present invention, which is a modification of the embodiment shown in Fig.2 and wherein vertical scan shift registers are provided for respective colors and a horizontal scan shift register is commonly used for all colors.

Fig.5 is an explanatory view of an embodiment of the present invention wherein a one pixel measuring unit is constructed of 3

x 3 photoelectric conversion units.

Fig.6 is an explanatory view illustrating the principle of an embodiment of the present invention wherein charge signals for each color in a one pixel are added.

Fig.7 is a particular circuit diagram embodying the principle of Fig.6.

Fig.8 is a circuit diagram of an embodiment of the present invention, wherein a one pixel measuring unit is constructed of 3 x 3 photoelectric conversion units and the charge storage time for each color can be changed.

Referring now to Fig.1 showing an embodiment of the arrangement of photoelectric conversion units of a color image sensor, the sensor 2 has alternately and regularly disposed red color photoelectric conversion units 3 for converting a red light into a charge signal and storing it, green color photoelectric conversion units 4 for converting a green light into a charge signal and storing it, and blue color photoelectric conversion units 5 for converting a blue light into a charge signal and storing it. The red, green and blue color photoelectric conversion units 3, 4 and 5 are each constructed of, as well known in the art, an equivalent photodiode and a color filter for selectively transmitting a specific color light. In this embodiment, red, green and blue filters are used as the color filters. The red color photoelectric conversion unit 3 is constructed of a red filter and a photodiode, the green color photoelectric conversion unit 4 is constructed of a green filter and a photodiode, and the blue color photoelectric conversion

unit 5 is constructed of a blue filter and a photodiode. To measure three colors separately, a one pixel measuring unit 2a is constructed of three photoelectric conversion units 3, 4 and 5 disposed laterally. In Fig.1, the one pixel measuring unit 2a is encircled with a solid line, while each photoelectric conversion unit 3, 4 and 5 is encircled with a dot line. The one pixel measuring unit 2a may be constructed of three photoelectric conversion units 3, 4 and 5 disposed vertically or slantwise. Although only a portion of the photoelectric conversion units is shown in Fig.1, actually a large number of photoelectric conversion units 3, 4 and 5 are disposed in a matrix fashion.

Fig.2 shows an embodiment of the color image sensor of the invention, wherein a one pixel measuring unit is constructed of one photoelectric conversion unit for each color and the charge storage time for each color can be varied. In an actual color image sensor, each electric element is integrally implemented on a semiconductor chip. However, in the figure, equivalent electric elements are used to represent such actual elements. Photodiodes 11to 16, 21 to 26, 31 to 35, and 41 to 44 are disposed in a matrix fashion for photoelectrically converting light through the above-noted color filter into a charge signal. The charge signal obtained through photoelectric conversion is stored in a floating capacitor. Photodiodes 11, 14, 23, 26, 32, 35, 41 and 44 are for red color. Photodiodes 12, 15, 21, 24, 33 and 42 are for green color. Photodiodes 13, 16, 22, 25, 31, 34 and 43 are for blue color. To read charge signals stored in these photodiodes, vertical MOS switches 71 to 76, 81 to 86, 91 to 95, and 101 to 104 are serially connected to respective photodiodes.

To conduct a high precision measurement by widening the dynamic range, vertical scan means is provided for each color in this embodiment. In particular, to vertically scan each color, a blue color vertical scan shift register 130a, green color vertical scan shift register 130b, and red color vertical scan shift register 130c are provided. In addition, to enable an independent readout for each color, e.g., to enable a concurrent readout for both red and green signals during some time, a blue color horizontal scan shift register 131a, green color horizontal scan shift register 131b, and red color horizontal scan shift register 131c are provided. The respective shift registers 130a to 130c and 131a to 131c are controlled by a controller 132. Reference numeral 133 designates a pulse generator for supplying pulses to the controller 132.

To scan the first row of the photoelectric conversion units, a blue color horizontal line 141a, green color horizontal line 141b, and red color horizontal line 141c are provided, which are respectively connected to output terminal D1 of the blue color vertical scan shift register 130a, output terminal D1 of the green color vertical scan shift register 130b, and output terminal D1 of the red color vertical scan shift register 130c. The gates of blue color vertical MOS switches 73 and 76 are connected to the blue color horizontal line 141a, the gates of green color vertical MOS switches 72 and 75 are connected to the green color horizontal line 141b, and the gates of red color vertical MOS switches 71 and 74 are connected to the red color horizontal line 141c. The same circuit arrangement is made for the second and following rows of the photoelectric conversion

units, so the description thereof is omitted.

A blue color vertical line 151a, green color vertical line 151b, and red color vertical line 151c are disposed aside along the first column of the photodiodes and connected to the corresponding drains of the vertical MOS switches. Three vertical lines 152a to 152c for respective colors are also disposed aside along the second column of the photodiodes. The same arrangement is used for the third and following columns so the description thereof is omitted.

The blue color vertical lines 151a, 152a, 153a, 154a, 155a, and 156a are connected to the respective sources of blue color horizontal MOS switches 161a, 162a, 163a, 164a, 165a, and 166a. The gates of these blue color horizontal MOS switches are connected to the respective output terminals F1 to F5 of the blue color horizontal scan shift register 131a. The drains of the blue color horizontal MOS switches 161a, 162a, 163a, 164a, 165a, and 166a are connected to a blue color output line 170a.

Similarly, the green color vertical lines 151b, 152b, 153b, 154b, 155b, and 156b are connected to the respective sources of green color horizontal MOS switches 161b, 162b, 163b, 164b, 165b, and 166b. The gates of these green color horizontal MOS switches are connected to the respective output terminals F1 to F5 of the green color horizontal scan shift register 131b. The drains of the green color horizontal MOS switches 161c, 162c, 163c, 164c, 165c, and 166c are connected to a green color output line 170b.

Furthermore, the red color vertical lines 151c, 152c, 153c,

154c, 155c, and 156c are connected to the respective sources of red color horizontal MOS switches 161c, 162c, 163c, 164c, 165c, and 166c. The gates of these red color horizontal MOS switches are connected to the respective output terminals F1 to F5. The drains of the red color horizontal MOS switches 161c, 162c, 163c, 164c, 165c, and 166c are connected to a red color output line 170c.

Next, the operation of the above embodiment will be described with reference to Fig.3. First, red, green and blue storage times are assigned to the controller 132. The charge storage times (photoelectric conversion times) are determined so that the maximum value obtained by measuring each color during pre-scan or the like becomes near the saturation output value. When a readout start signal for a main scan is inputted to the controller 132, respective charge signals stored in the floating capacitors are scanned by the vertical scan shift registers 130a to 130c and the horizontal scan shift registers 131a to 131c, and simultaneously read to reset at time t0. These read-out signals are not needed so that they are not inputted to the computer but drained.

After time t0, each photodiode converts incident light into a charge signal and stores it. At time t1, the red color charge storage is complete. Then, the controller 132 sends clock pulses to the red color vertical scan shift register 130c and red color horizontal scan shift register 131c to sequentially scan the red color photodiodes and read the charge signals stored therein. More particularly, the red color vertical scan shift register 130c outputs a shift pulse from the first output terminal D1 to

supply it to the red color horizontal line 141c. With this state, the red color horizontal scan shift register 131c scans once to sequentially turn ON the red color MOS switches 161c to 166c. The charge signals stored in the red color photodiodes 11 and 14 at the first row are sequentially read as analog signals, which are in turn sent via the red color output line 170c to an A/D converter (not shown) where they are converted into digital signals. The digital signals are sent to a logarithm conversion table (not shown) where they are subjected to logarithmic conversion. At this logarithmic conversion a page corresponding to the charge storage time is selected to convert the digital signals into correct density values suitable for the respective charge storage times. The density values are inputted to the computer.

After completion of the readout of the red color photodiodes at the first row, the red color vertical scan shift register 130c outputs a shift pulse from the second output terminal D2. With this state, the red color horizontal scan shift register 131c scans once as described above to read the charge signals stored in the photodiodes at the second row. Similarly, the red color photodiodes at the third and following rows are scanned to sequentially read the red color charge signals. The red color charge signal readout continues during time t1 to time t2.

At time t3 the charge storage for green color completes. Then the controller 132 outputs a shift pulse to the green color vertical scan shift register 130b and green color horizontal scan shift register 131b to sequentially scan the green color photodiodes and read the stored charge signals during time t3 to t4.

At time t5 the charge storage for blue color completes. Then, the blue color photodiodes are sequentially scanned by the blue color vertical scan shift register 130a and the blue color horizontal scan shift register 131a. The stored charge signals are read during time t5 to t6.

In case where the concurrent readout for respective colors does not occur, a single horizontal scan shift register can be commonly used, resulting in a simple circuit arrangement and inexpensive cost. Fig.4 shows such an embodiment, wherein substantially the same elements as those in Fig.2 have been designated by identical references. The single horizontal scan shift register 131 operates three times to read respective color signals. The other operations are substantially the same as those in Fig.2, so the description thereof is omitted. Although horizontal MOS switches are provided for each color, other modifications are possible. For example, only one horizontal MOS switch may be used and the three vertical lines coupled together. In this case, three color signals are read from the same output line. However, the three color signals are different in time and are separated from each other.

In case where a one pixel measuring unit is constructed of a single photoelectric conversion unit, the photoelectric conversion unit for each color measures a different point on a color original so that the color registration error may become great. To eliminate color registration error, the photoelectric conversion units may be grouped into units each constructed of _M_ rows and _N_ columns (_M_ and _N_ are integers 3 or larger), and a one pixel measuring unit is constructed of _M_ x _N_ photoelectric

conversion units. The same color charge signals of the photoelectric conversion units within the one pixel measuring unit are read and added together so that a three color separation measurement can be performed without any substantial hindrance against the exposure control for a color printer. Fig.5 shows an embodiment of the color image sensor wherein a one pixel measuring unit is constructed of 9 or 3 rows and 3 columns of photoelectric conversion units. Identical elements to those in Fig.1 have been designated by the same references. In this embodiment, a one pixel measuring unit 2b is constructed of three red color photoelectric conversion units 3, three green color photoelectric conversion units 4 and three blue color photoelectric conversion units 5. In Fig.5, each photoelectric conversion unit 3 through 5 is encircled by a dot line, while the one pixel measuring unit 2b is encircled by a solid line.

Fig.6 is a schematic diagram illustrating the operating principle of the one pixel measuring unit. The same color charge signals stored in the photoelectric conversion units within the one pixel measuring unit 2b are simultaneously read and added together by an adder. In particular, the signals read out of three blue color photoelectric conversion units 5 are added by an adder 180a, the signals read out of three green color photoelectric conversion units 4 are added by an adder 180b, and the signals read out of three red color photoelectric conversion units 3 are added together by an adder 180c. The adders 180a to 180c may be provided for each row or column of pixels, instead of each pixel. In addition, the adders may be mounted outside of the color image sensor 2.

Fig.7 is a particular circuit diagram for the embodiment shown in Fig.6. The identical elements to those in Fig.2 have been designated by the same references, and the elements used commonly for each color have been designated by the references omitting letters. In this embodiment, the one pixel measuring unit 2b is constructed of 3 rows. Therefore, to simultaneously read the charge signals stored in the photodiodes within the one pixel measuring unit and add together, the upper three horizontal lines 141 to 143 are connected together to the first stage output terminal D1 of a vertical scan shift register 130. Similarly, the fourth to sixth horizontal lines 144 to 146 are connected together to the second stage output terminal D2 of the vertical scan shift register 130.

The one pixel measuring unit 2b is also constructed of 3 columns. Therefore, blue color vertical lines 151a, 152a and 153a are coupled together and connected serially to a blue color horizontal MOS switch 161a. Similarly, green color vertical lines 151b, 152b and 153b are coupled together and connected serially to a green color horizontal MOS switch 161b. Red color vertical lines 151c, 152c and 153c are coupled together and connected serially to a red color horizontal MOS switch 161c. The gates of these horizontal MOS switches 161a to 161c are connected to the first stage output terminal F1 of a horizontal scan shift register 131.

Similarly, to simultaneously read the charge signals for each color within the one pixel measuring unit at the second column and add together, there are provided a blue color horizontal MOS switch 162a, green color horizontal MOS switch

162b and red color horizontal MOS switch 162c. The gates of these horizontal MOS switches 162a to 162c are connected to the second stage output terminal F2 of the horizontal scan shift register 131.

Next, the operation of the color image sensor of Fig.7 will be described. For reading charge signals, first the vertical scan shift register 130 outputs a vertical scan pulse from the first stage output terminal D1. With this state, the horizontal scan shift register 131 sequentially outputs a horizontal scan pulse shifting from the output terminal F1 to the output terminal F2. First, when a horizontal scan pulse is outputted from the first stage output terminal F1, the horizontal MOS switches 161a to 161c turn ON, while the vertical MOS switches 71 to 73, 81 to 83, and 91 to 93 turn ON. As a result, the charge signals are simultaneously read from the one pixel measuring unit constructed of 3 rows and 3 columns. In this case, since the vertical lines are connected together for each color, the charge signals stored in the blue color photodiodes 13, 22 and 31 are added together and outputted via the blue color horizontal MOS switch 161a onto a blue color output line 170a. Simultaneously therewith, the charge signals stored in the green color photodiodes 12, 21 and 33 are added together and outputted via the green color horizontal MOS switch 161b onto a green color output line 170b. Also, the charge signals stored in the red color photodiodes 11, 23 and 32 are added together and outputted via the red color horizontal MOS switch 161c onto a red color output line 170c. Consequently, the charge signals stored in the photodiodes within the 3 x 3 one pixel are simultaneously read and added together

for each color for outputting them in a color separated state.

Succeedingly, the horizontal scan shift register 131 outputs a horizontal scan pulse from the second stage output terminal F2 to simultaneously turn ON the horizontal MOS switches 162a to 162c. Accordingly, nine photodiodes of the one pixel measuring unit at the first row and at the second column are scanned. The charge signals are added together for each color and the added signal is outputted in a color-separated state onto the output lines 170a to 170c.

At the end of scanning of the horizontal shift register 131, reading charge signals of the first row photodiodes within the one pixel measuring unit is terminated. Next, the vertical scan shift register 130 outputs a vertical scan pulse from the output terminal D2. With this state, the horizontal shift register 131 scans once so that the one pixel measuring unit at the second row is sequentially scanned starting from the first column. Thus, the charge signals of the photodiodes are added together and outputted. Similarly, the remaining photodiodes are scanned for each one pixel measuring unit and the read-out signals are added together for each color and outputted onto the output lines 170a to 170c.

Fig.8 is a modification of the circuit of Fig.7, wherein occurrence of color registration error is avoided and the charge storage time can be set as desired for each color. The identical elements to those in Fig.2 have been designated by the same references. In this embodiment, to enable a readout of the charge signal independently of each color, a vertical scan shift register is provided for each color, i.e., there are provided a

blue color vertical scan shift register 130a, green color vertical scan shift register 130b and red color vertical scan shift register 130c. To read the charge signals in units of each one pixel measuring unit 2b, blue color horizontal lines 141a, 142a and 143a are coupled together and connected to the first stage output terminal D1 of the blue color vertical scan shift register 130a. Similarly, green color horizontal lines 141b, 142b and 143b are coupled together and connected to the first stage output terminal D1 of the green color vertical scan shift register 130b. Red color horizontal lines 141c, 142c and 143c are coupled together and connected to the first stage output terminal D1 of the red color vertical scan shift register 130c. The connection arrangement of the one pixel measuring unit of the second or following row can be readily thought of from that of the first row described above, so the description thereof is omitted. The connection arrangement of the vertical lines are the same as that of Fig.7.

Similarly to the circuit of Fig.2, in the circuit of Fig.8, by driving any one of the vertical shift registers 130a to 130c at a desired readout timing, it is possible to control the charge storage time for each color and the added charge signals within one pixel measuring unit for the same color can be read. In case the concurrent readout of the charge signals occurs, the horizontal shift register may be provided for each color as shown in Fig.2.

In the above embodiments, the shift registers connected to the horizontal lines are called vertical scan shift register, while the shift registers connected to the vertical lines are

called horizontal scan shift register. This designation, however, should be construed that the terms "vertical and horizontal" only mean the relative position between the register and the line. The present invention is not intended to be limited to the above embodiments, but various applications and modifications are possible without departing from the scope of the appended claims.

Claims

1. A color image sensor wherein a plurality of types of photoelectric conversion units are alternately disposed for photoelectrically converting different color lights into charge signals and storing the charge signals, and the stored charge signal in each of the photoelectric conversion units is read, comprising

readout means provided in correspondence with the types of said photoelectric conversion units for reading said charge signals in a color separated state.

2. A color image sensor according to claim 1, wherein said plurality of types of photoelectric conversion units include a red color photodiode for storing a charge signal obtained through photoelectric conversion of a red color light, a green color photodiode for storing a charge signal obtained through photoelectric conversion of a green color light, and a blue color photodiode for storing a charge signal obtained through photoelectric conversion of a blue color light, said photodiodes being disposed in a matrix fashion.

3. A color image sensor according to claim 2, wherein said readout means comprises: a red color vertical MOS switch serially connected to said red color photodiode ; a green color vertical MOS switch serially connected to said green color photodiode; a blue color vertical MOS switch

serially connected to said blue color photodiode ; a red color horizontal MOS switch serially connected to said red color vertical MOS switch: a green color horizontal MOS switch serially connected to said greed color vertical MOS switch ; a blue color horizontal MOS switch serially connected to said blue color vertical MOS switch: vertical scan means for turning on said vertical MOS switches ; and horizontal scan means for turning on said horizontal MOS switches.

4. A color image sensor according to claim 3, wherein said vertical scan means comprises: a red color vertical scan shift register for sequentially turning on said red color vertical MOS switch one row after another; a green color vertical scan shift register for sequentially turning on said green color vertical MOS switch one row after another; and a blue color vertical scan shift register for sequentially turning on said blue color vertical MOS switch one row after another.

5. A color image sensor according to claim 4, wherein said horizontal scan means comprises: a red color horizontal shift register for sequentially turning on said red color horizontal MOS switch one column after another; a green color horizontal shift register for sequentially turning on said green color horizontal MOS switch one column after another; and a blue color horizontal shift register for sequentially turning on said blue color horizontal MOS switch

one column after another.

6. A color image sensor according to claim 4, wherein said horizontal scan means is a single horizontal scan shift register for simultaneously turning on said blue color horizontal MOS switch, said green color horizontal MOS switch and said red color horizontal MOS switch.

7. A color image sensor according to claim 2, wherein said photodiodes are disposed two-dimensionally and grouped into units each constructed of M rows and N columns (M and N are integers 3 or larger), and said readout means for each color read the charge signals in units of said grouped unit and read the charge signals stored in the same color photodiodes of each said grouped unit.

8. A color image sensor according to claim 7, wherein said readout means comprises: blue color vertical MOS switches serially connected to said respective blue color photodiodes; green color vertical MOS switches serially connected to said respective green color photodiodes; red color vertical MOS switches serially connected to said respective red color photodiodes; a blue color horizontal MOS switch provided for said N columns and connected to a plurality of blue color vertical MOS switches in said N

columns; a green color horizontal MOS switch provided for said N columns and connected to a plurality of green color vertical MOS switches in said N columns; a red color horizontal MOS switch provided for said N columns and connected to a plurality of red color vertical MOS switches ; a single vertical scan shift register for sequentially turning on said blue color, green color and red color vertical MOS switches for said M rows; and a single horizontal scan shift register for sequentially turning on said blue color, green color and red color horizontal MOS switches for said N rows.

9. A color image sensor according to claim 8, wherein said integers M and N are 3.

10. A color image sensor according to claim 7, wherein said readout means comprises: blue color vertical MOS switches serially connected to said respective blue color photodiodes ; green color vertical MOS switches serially connected to said respective green color photodiodes ; red color vertical MOS switches serially connected to said respective red color photodiodes; a blue color horizontal MOS switch provided for said N columns and connected to a plurality of blue color vertical MOS switches in said N columns; a green color horizontal MOS switch provided for said N columns and connected to a plurality of green color vertical MOS switches in said N columns; a red color

horizontal MOS switch provided for said N columns and connected to a plurality of red color vertical MOS switches; a blue color vertical scan shift register for sequentially turning on said blue color vertical MOS switches for said M columns; a green color vertical scan shift register for sequentially turning on said green color vertical MOS switches ; a red color vertical scan shift register for sequentially turning on said red color vertical MOS switches ; and a single horizontal scan shift register for sequentially turning on said blue color, green color and red color horizontal MOS switches for said N rows.

11. A color image sensor according to claim 10, wherein said integers M and N are 3.

12. Color image sensors substantially as hereinbefore described with reference to any of the Figures of the accompanying drawings.

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Amendments to the claims have been filed as follows

1. A colour image sensor wherein a plurality of types of photoelectric conversion units are alternately disposed for photoelectrically converting different colours of light into charge signals and storing the charge signals, and the stored charge signal in each of the photoelectric conversion units is read, wherein said plurality of types of photoelectric conversion units includes a first photodiode for storing a charge signal obtained through photoelectric conversion of a first colour light, a second photodiode for storing a charge signal obtained through photoelectric conversion of a second colour light, and a third photodiode for storing a charge signal obtained through photoelectric conversion of a third colour light, said photodiodes being arranged in a matrix, comprising: readout means for each of said types of said photoelectric conversion units for reading said charge signals in a colour-separated state, said readout means comprising a first vertical MOS switch serially connected to said first photodiode; a second vertical MOS switch serially connected to said second photodiode; a third vertical MOS switch serially connected to said third photodiode; a first horizontal MOS switch serially connected to said first vertical MOS switch; a second horizontal MOS switch serially connected to said second vertical MOS switch; a third horizontal MOS switch serially connected to said third vertical MOS switch; vertical scan means for turning on said vertical MOS switches, said vertical scan means comprising a first vertical scan shift register for turning on rows of said first vertical MOS switches, a second vertical scan shift register for turning on rows of said second vertical MOS switches, and a third vertical scan shift register for turning

on rows of said third vertical MOS switches, the first, second and third vertical scan shift registers being operable independently of one another; and horizontal scan means for turning on said horizontal MOS switches.

2. A colour image sensor as claimed in claim 1 wherein said horizontal scan means comprises a first horizontal shift register turning on columns of said first horizontal MOS switches, a second horizontal shift register for turning on columns of said second horizontal MOS switches, and a third horizontal shift register for turning on columns of said third horizontal MOS switches, the first, second and third horizontal scan shift registers being operable independently of one another.

3. A colour image sensor as claimed in claim 1 wherein said horizontal scan means comprises a single horizontal scan shift register for turning on said first horizontal MOS switches, said second horizontal MOS switches and said third horizontal MOS switches.

4. A colour image sensor as claimed in claim 1 wherein said units comprise said first, second and third photodiodes arranged in a matrix of M rows and N columns, where M and N are integers equal to at least three and wherein said first vertical scan shift register is arranged for turning on M rows of said first vertical MOS switches simultaneously, said second vertical scan shift register is arranged for turning on M rows of said second vertical MOS switches simultaneously, and said third vertical scan shift register is arranged for turning on M rows of said third vertical MOS switches simultaneously.

5. A colour image sensor as claimed in any preceding claim wherein said first colour is red, said second colour is green and said third colour is blue.

6. Colour image sensor substantially as hereinbefore described with reference to Figures 1 to 4 of the accompanying drawings.